DIPTERA LARVAE (EMPIDIDAE AND CHIRONOMIDAE) IN TRICHOPTERA PUPAL CASES (GLOSSOSOMATIDAE AND LIMNEPHILIDAE)[1]

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ABSTRACT: Larvae of Empididae and Chironomidae (Diptera) were collected from pupal cases of the Trichoptera species *Glossosoma intermedium*, *Hesperophylax designatus*, and *Neophylax concinnus*. Partially consumed caddisflies within several cases containing empidids verifies implications in the literature that dance flies feed upon immature caddisflies (ectoparasitism). *Eukiefferiella* was the most frequently encountered midge within trichopteran pupal cases, with *Corynoneura*, *Cricotopus*, and *Polypedilum* also observed. It was concluded that the midges occupied the cases to obtain detrital food and to escape current and/or predators, rather than to prey upon the caddisflies (inquilinism). These interactions, particularly when parasitic, may contribute to the regulation of caddisfly populations.

Direct relationships between Diptera and Trichoptera are poorly known. Published reports suggest inquilinism, sometimes accompanied by ectoparasitism, with either Chironomidae (Gallepp, 1974; Parker and Voshell, 1979) or Empididae (Knutson and Flint, 1971; 1979) occurring within Trichoptera pupal cases. Our studies support these findings and add to the list of chironomid inhabitants and infested trichopteran species.

STUDY SITE AND METHODS

Trichoptera were collected from two spring and seepage-fed brooks at Trout Park Nature Preserve (Elgin Botanical Garden), Elgin, Illinois, USA, which is a 10.5-hectare tract along the east bluff of the Fox River. Brook widths ranged from <0.3 to 2 m with depths from <5.0 cm to ~ 1.0 m. Water temperatures at the springs were ~ 11.0 C. Sampling dates were April 7, April 25, and May 6, 1980. Trichoptera were collected by hand and stored individually in vials with 70% ethyl alcohol. The pupal cases were opened under a dissecting microscope. The caddisflies were classified as prepupae (here including true prepupae and pupal stages prior to larval-pupal ecdysis) or pupae (period beginning with larval-pupal ecdysis) (see Wiggins, 1977). Occurrence of dipterans in the cases were noted, and midges mounted for identifications. Identification followed Hilsenhoff (1975) (Diptera) and Ross (1944) (Trichoptera).

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RESULTS AND DISCUSSION

On April 7, 1980, two of 24 pupal cases of *Hesperophylax designatus* (Trichoptera: Limnephilidae) and two of 32 cases of *Glossosoma intermedium* (Trichoptera: Glossosomatidae) contained an Empididae larva. The empidid larvae were within decomposed remains of *H. designatus* but outside of the intact pupal cocoons in *G. intermedium*. Two sediment-ladened *Glossosoma* pupal cases (without the caddisfly) contained a larva of *Cricotopus* (Chironomidae) in one case and *Eukiefferiella* (Chironomidae) in the other. Flint (1980, personal communication) stated that it is not uncommon to observe Chironomidae inhabiting sediment-filled trichopteran cases that have been abandoned by the caddisfly. Our findings prompted a more intensive search for dipterans inhabiting pupal cases of these two trichopteran species. A total of 42 prepupae and 66 pupae of *G. intermedium* and 25 prepupae and 38 pupae of *H. designatus* were collected from the brooks, April 25, 1980.

Occurrence of Diptera within the caddisfly pupal cases are summarized in Tables 1 (for *Glossosoma*) and 2 (for *Hesperophylax*). Chironomids were encountered more frequently than empidids, with *Glossosoma*

Table 1. Occurrence of Diptera within pupal cases of ***Glossosoma intermedium.***

Stream	Cases Containing Chironomidae	Cases Containing Empididae	Total Cases Examined	% Infestation
		Prepupae		
1	12	2	32	43.8
2	1	0	11	9.1
		Pupae		
1	8	7*	20	70.0
2	15	0	46	32.6

*One case with an empidid and a chironomid.

Table 2. Occurrence of Diptera within pupal cases of ***Hesperophylax designatus.***

Stream	Cases Containing Chironomidae	Cases Containing Empididae	Total Cases Examined	% Infestation
		Prepupae		
1	0	0	8	0.0
2	0	0	17	0.0
		Pupae		
1	8	1	24	37.5
2	7	0	14	50.0

generally having a higher rate of infestation than *Hesperophylax*. The latter observation is due in part to the greater ease of penetration between stones (or under the sides) of *Glossosoma* cases compared to those of *Hesperophylax*. Additionally, *Glossosoma* were collected on the tops or sides of cobble in the main stream where Diptera would more likely seek trichopteran cases to escape the current. In contrast, *Hesperophylax* was collected from crevices on the undersides of wood debris (areas already protected from main current velocities). Complete closure of the *Hesperophylax* case in preparation for pupation would also increase the difficulty of case entry by dipterans.

Glossosoma prepupae and pupae from Stream 1 had a higher percentage of infestation than did those from Stream 2 (Table 1). The major environmental difference between the two streams was that Stream 1 had a large quantity of watercress and fallen logs which allowed pools containing finely deposited sediments to develop. Larger populations of dipterans could inhabit these pooled areas in comparison to the normally encountered, fast-flowing riffle areas. From each respective stream, *Glossosoma* cases containing pupae had a higher percentage of infestation than did those containing prepupae. Time lapsed between development from prepupae to pupae (age-factor) would allow for an increased potential for case invasion by the dipterans. Similarly, no *Hesperophylax* prepupae were infested, while 37.5 and 50.0% of the pupae from Stream 1 and Stream 2 respectively, contained dipterans (Table 2).

Empidids were only encountered in pupal cases collected from Stream 1. Historically, this stream has received the greatest disturbance due to storm sewer runoff (Unzicker and Sanderson, 1974). Impacts have included erosion and subsequent tree fall which have created pooled areas, decreased sediment size, and increased amounts of filamentous algae and wood debris in the stream. These conditions provide preferred habitats for larval empidids (see Merritt and Cummins, 1978). During drift or random movement, the empidids can encounter and infest trichopteran cases. Empidids may also enter glossosomatid cases in search of midges as a food source. The high infestation rates of *Glossosoma* cases by midges, accompanied by high densities of *Glossosoma*, could provide an abundant food resource for the empidids. The midges are easier to prey upon than the glossosomatids, as the empidid would have to penetrate the sheath of the pupal cocoon to feed on the caddisfly. In most instances when empidids were found, the sheath of the glossosomatid cocoon was intact. Only once were two empidids found in a *Glossosoma* case. In one instance an empidid was associated with a larval *Glossosoma* within a case from which the ventral strap had been removed in preparation for pupation. Therefore, the potential exists for empidid predation upon larval caddisflies in the field, a fact that has been observed in the laboratory by Sommerman (1962).

The observation of several partially consumed caddisfly specimens in *Hesperophylax* pupal cases containing empidids confirms Knutson and Flints' findings (1971, 1979) that empidids do feed upon Trichoptera. Their observations of pupal empidids within the cocoons of glossosomatid and rhyacophilid pupal cases leads to speculation as to whether the Trichoptera died from crowding or from predation. The small size of the empidid larva relative to both the pupal and case size of *H. designatus* (e.g. empidid larval length <3.0 mm and *Hesperophylax* larval and pupal lengths > 15.0 mm) would preclude the crowding option in favor of predation (ectoparasitism), at least for this species of Trichoptera.

Of midges collected from pupal caddisfly cases, *Eukiefferiella* was most prevalent, with *Corynoneura* encountered in two cases from each trichopteran species (Table 3). A *Polypedilum* and a *Cricotopus* were each collected from separate *Glossosoma* cases. In most instances only one midge was found in a case. However, on April 25 over 10% of the cases contained more than one midge (five glossosomatid cases contained two to three midges and two *Hesperophylax* cases contained two midges). The caddisflies in cases occupied by midges were seldom injured or dead. This may be due to the smaller instar or species sizes of the midges usually encountered. Gallepp (1974) found *Brachycentrus occidentalis* pupae to be seldom damaged when cases contained early instar *Eukiefferiella*. Given adequate development time the *Eukiefferiella* could result in the death of the host trichopteran (particularly *Glossosoma*) by crowding in the manner reported by Gallepp (1974). Considering the algal and detrital food preferences for the collected midges (Roback, 1953; Darby, 1962; Oliver, 1971), it would appear that the midges entered the trichopteran cases to escape the current or predators and/or to obtain non-trichopteran food resources rather than to prey upon the caddisfly. This is supported by our observations of diatoms in the gut contents of some of the midges and by the apparent lack of damage to most of the caddisfly specimens.

Further support of the inquilinous nature of midge larvae was obtained on May 6, 1980. *Glossosoma* pupal cases were again found to contain

Table 3. Chironomidae within Pupal Cases of ***G. intermedium*** and ***H. designatus.***

	Chironomidae (Percentage)			
Trichoptera	Stream 1		Stream 2	
Glossosoma intermedium	*Eukiefferiella*	(95.0)	*Eukiefferiella*	(81.3)
	Cricotopus	(5.0)	*Corynoneura*	(12.5)
			Polypedilum	(6.2)
Hesperophylax designatus	*Eukiefferiella*	(87.5)	*Eukiefferiella*	(85.7)
	Corynoneura	(12.5)	*Corynoneura*	(14.3)

Eukiefferiella. However, an empty, sediment-ladened case collected from a different area contained three *Cricotopus* larvae. In this are *Cricotopus* was the dominant midge found in the substrate. In all other areas, especially where the April collections were made, *Eukiefferiella* dominated. In addition, on May 6, two prepupal *Neophylax concinnus* were found, each containing a *Eukiefferiella*. These were the only *N. concinnus* cases out of 61 prepupae that contained midges. The compact nature of *Neophylax* within its case, as well as the tightly bound structure of the case, would make this case more difficult to enter and inhabit. However, once entered it would appear that a midge could more readily crowd the caddisfly, and this could lead to its death. Considering that mode *Neophylax* final instar larvae diapause for up to several months (Wiggins, 1977), adequate time could pass for midge growth to occur allowing for crowding by the midge larvae. This could ultimately interfere with or inhibit the respiration of the caddisfly.

Thus, the symbiotic midge-caddisfly interrelationship is a case of inquilinism without accompanying ectoparasitism, being similar to that observed by Gallepp (1974). The interaction between *Cardiocladius* and Hydropsychidae reported by Parker and Voshell (1979) was both inquilinism and ectoparasitism, as are the interactions of empidids and trichopterans observed by Knutson and Flint (1971, 1979) and us. We also observed apparent inquilinism involving unidentifiable, immature tubificid worms and *Glossosoma*, these worms being found in several cases also containing midges.

To date the occurrence of Diptera within Trichoptera pupal cases has been seldom reported. However, considering the geographical range of the reports, i.e. South America (Knutson and Flint, 1971; 1979), Wisconsin (Gallepp, 1974), Virginia (Parker and Voshell, 1979), and Illinois (present study), it would appear that symbiotic relationships between these two orders commonly occur but are often overlooked in collections. Considering the percentage of pupal caddisflies infested, i.e. 32% (Gallepp, 1974), as much as 61% (Parker and Voshell, 1979), and up to 75% in our study, these interactions may significantly affect the numbers of caddisflies reaching maturity. Therefore, dipterans may play an important role in regulation of trichopteran population sizes, especially in a situation such as that present at Trout Park where populations of large predatory insects and fish are low (Vinikour and Anderson, 1980).

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LITERATURE CITED

Darby, R.E. 1962. Midges associated with California rice fields, with special reference to their ecology (Diptera: Chironomidae). Hilgardia 32: 1-206.

Gallepp, G.W. 1974. Behavioral ecology of *Brachycentrus occidentalis* Banks during the pupation period. Ecol. 55: 1283-1294.

Hilsenhoff, W.L. 1975. Aquatic insects of Wisconsin with generic keys and notes on biology, ecology, and distribution. Wisconsin Dept. Nat. Res., Tech. Bull. No. 89, 53 pp.

Knutson, L.V. and O.S. Flint, Jr. 1971. Pupae of Empididae in pupal cocoons of Rhyacophilidae and Glossosomatidae (Diptera-Trichoptera). Proc. Entomol. Soc. Wash. 73(3): 314-320.

__________. 1979. Do dance flies feed on caddisflies? — Further evidence (Diptera: Empididae; Trichoptera). Proc. Entomol. Soc. Wash. 81(1): 32-33.

Merritt, R.W. and K.W. Cummins (eds.). 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Publishing Company, Dubuque. 441 pp.

Oliver, D.R. 1971. Life history of the Chironomidae. Ann. Rev. Entomol. 16: 211-230.

Parker, C.R. and J.R. Voshell, Jr. 1979 *Cardiocladius* (Diptera: Chironomidae) larvae ectoparasitic on pupae of Hydropsychidae (Trichoptera). Environm. Entomol. 8: 808-809.

Roback, S.S. 1953. Savannah River tendipedid larvae [Diptera: Tendipedidae (=Chironomidae)]. Proc. Acad. Nat. Sci. Phila. 115: 91-132.

Ross, H.H. 1944. The caddis flies, or Trichoptera, of Illinois. Bull. Ill. Nat. Hist. Surv., 23(1): 1-326.

Sommerman, K.M. 1962 Notes on two species of *Oreogeton* predaceous on black fly larvae (Diptera: Empididae and Simuliidae). Proc. Entomol. Soc. Wash. 54: 123-129.

Unzicker, J.D. and M.W. Sanderson. 1974. Untitled report to Illinois Nature Preserves Commission from the Illinois State Natural History Survey on their examination of Elgin Botanical Gardens (Trout Park). Dated July 10, 1974. 2 pp. typed.

Vinikour, W.S. and R.V. Anderson. 1980. First confirmed records of fish (*Cottus bairdi*) from Trout Park Nature Preserve (Elgin Botanical Gardens) since park perturbation by I-90 construction, 1957. Trans. Ill. Acad. Sci. 72(2): 97-99.

Wiggins, G.B. 1977. Larvae of the North American caddisfly genera (Trichoptera). University of Toronto Press, Toronto, 401 pp.